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BUILDING WITH LOW-EMITTING MATERIALS AND PRODUCTS: WHERE DO WE STAND?

W. Gene Tucker
Air and Energy Engineering Research Laboratory
U. S. Environmental Protection Agency
Research Triangle Park, NC

One way to help ensure good indoor air quality (IAQ) is to use materials and products with low emissions of substances that can cause health or comfort problems. Over the past several years, research and development of product testing procedures and exposure prediction models have produced useful tools for evaluating the acceptability of building materials, furnishings, and other products used in buildings. Emission testing and prediction of occupant exposures has recently become a key step in the design of some major office building projects. This paper gives three examples of material and product selection criteria, proposes emissions criteria for judging the acceptability of products, and discusses future directions in product testing for prevention of IAQ problems.

INTRODUCTION

Many indoor air quality (IAQ) problems can be prevented during building design. While the importance of proper design of ventilation systems has long been recognized, selection of materials and products is now receiving increased attention. It is important to avoid sources with emissions that are too great to be diluted and exhausted by ventilation, or removed by air cleaning devices. This is especially true for sources that are close to occupants, such as office furniture, furnishings, office supplies, and personal care products. It is also true for many sources that release large quantities of pollutants over short periods of time; their emissions can be adsorbed on many indoor surfaces (sinks) that subsequently re-emit the pollutants and become significant sources themselves.

The best currently available approach to evaluating indoor materials and products is to test their emission rates, and predict pollutant concentrations in the building where they are to be used. This approach has been described previously (1)(2). While there are very few standards to guide the building designer on acceptable concentrations of indoor air pollutants, some general guidelines do exist (3)(4). Emission testing and prediction of occupant exposures has recently become a key step in the design of some major office buildings. This paper summarizes the selection criteria being used in these projects, proposes definitions for low-emitting materials and products, and makes some predictions as to what lies ahead in product testing for prevention of IAQ problems.

EXAMPLES OF MATERIAL AND PRODUCT SELECTION CRITERIA

Approach Being Considered for New and Renovated U.S. EPA Buildings

Several cases of IAQ problems in office buildings in the U.S. have been widely publicized. To help avoid such problems in its new and renovated buildings, EPA has begun to emission-test several products and is considering the following evaluation approach:

1. Require emissions rate testing data from manufacturers or suppliers of the following types of materials and products: coatings (paints, varnishes, waxes); flooring or wall covering materials made of plastics, fibers, or fabrics; adhesives (e.g., for floor or wall coverings); furniture or furnishings with substantial amounts of pressed wood or fabrics; non-metallic materials used in the ductwork of the ventilation system; office machines; supplies (e.g., coated papers); and maintenance materials (e.g., floor waxes, restroom odorizers).
2. Require that the manufacturer or supplier provide Material Safety Data Sheets for chemicals used in the manufacture of each product.
3. Require from manufacturers or suppliers an **emissions rate testing report** that documents: emission factors for the five major organic compounds emitted and for any specified compounds (e.g., compounds known to be in the product that are toxic or irritating at an air concentration of 5 mg/m³ or less); emission factors at three "ages" of the product (for coatings, adhesives, and caulks approximately 1, 10, and 100 hours after application to a surface; for solid materials approximately 0-1, 10, and 50 days after production); ozone emission rates for office machines; chamber testing conditions; and product storage and handling procedures used.
4. Model indoor concentrations and employee inhalation exposures, as a function of time, for the building design conditions and product applications being considered.
5. Reject, or evaluate conditioning of, materials or products that are likely to increase organic vapor concentrations by 0.5 mg/m³ or more; reject machines that increase ozone concentrations by more than 0.01 ppm in an occupied space.
6. Evaluate (by IAQ modeling scenarios) the likely benefits of product conditioning before use, and ventilation strategies for the building.
7. Conduct quality assurance checks on selected data supplied by manufacturers or suppliers.

State of Washington Approach

One of the most progressive approaches is being taken in the State of Washington, where four new state office buildings will be built over the next 2 years. Approximately \$10 million of office furniture will be purchased, and previous IAQ problems convinced officials that purchase of low-emission products would be prudent. Suppliers are required to submit data on emissions with their bids, and the successful bidder will have to submit quality control data on furniture that is actually supplied (5). Modeling for exposure will use an IAQ prediction model of the type by Sparks (6). The State has set the acceptability criteria summarized below:

1. As part of its "Healthy Buildings" program for new State-owned office buildings, Washington requires various design and operational features to achieve good indoor air quality. One of the design considerations is selection of materials and furnishings that meet emissions criteria. The criteria for systems office furniture (workstations) are emission rates that will result in building air concentrations less than:

0.05 ppm (60 ug/m³) of formaldehyde,
 0.50 mg/m³ (500 ug/m³) of total volatile organic compounds (VOCs), and
 50 ug/m³ of total particles.

2. Emissions of IARC category 1, 2, 2A, and 2B carcinogens, compounds on the cancer list of the National Toxicology Program, and reproductive toxins listed in the latest edition of the Catalog of Teratogenic Agents must also be identified and quantified. Emissions of the compounds should be eliminated or reduced as much as technologically feasible.
3. Compliance with above specifications is required prior to final bid specifications.
4. Large-chamber testing of emissions from workstation setups is required, using test procedure guidance from report EPA-600/8-89-074 (ref. 7). Several specific requirements regarding chamber design and operation, handling and packaging of the furniture prior to testing, and installation of the workstations in the chambers have also been spelled out.
5. Emission testing covers a 6-week period, to obtain data on emission rate changes.
6. An appropriate IAQ model will be used to predict indoor pollutant concentrations, based on the building and ventilation system design specifications. Air concentrations determined by this model will determine compliance or non-compliance with the pollutant concentration specifications.

A Private Sector Approach

Several large building projects in the U.S. are using the following approach to specifying materials and products in their building design requirements [See refs. (8) and (9) for further details]:

General Conditions: Materials shall be designed, manufactured, handled, installed, and maintained in a manner that will produce the least harmful effects on occupants of the building. Manufacturers shall avoid unnecessary use of chemicals that are toxic or irritating in the manufacture, treatment, or handling of their products. Manufacturers shall implement measures to reduce installed-product emissions of chemicals that are toxic or irritating. Suppliers or installers shall submit the following before authorization to proceed will be issued by the architect: a list of all chemicals used in the manufacture of the product (including a breakdown of the contents by weight or volume); a description of any procedures used by the manufacturer to minimize the emissions of VOCs from its product(s); a description of all emission testing performed; and a listing of all chemicals in the product that are considered carcinogens by the U.S. EPA or the State of California, or are covered by California's Proposition 65. (These requirements are included in the general conditions of the design specifications, and therefore apply to all materials used in the building. Listed below are specific materials for which the general conditions are amplified.)

Carpet: Consider conditioning the carpet prior to installation, to reduce residual levels of VOCs. Require that the heating, ventilating, and air-conditioning (HVAC) system be in operation during and immediately after installation of the carpet. If possible, temporarily operate the HVAC system in a once-through mode (100% outdoor air).

Carpet Adhesives: Require that the adhesive specification by the carpet manufacturer provide for the smallest quantity of adhesive consistent with the requirements of product application. Require that the adhesive have the lowest content of toxic or irritating chemicals while meeting other requirements. Require the manufacturer to submit results from testing such as drying times, emission tests of VOCs, or any other tests that will allow evaluating the impact of the carpet adhesive on IAQ.

Vinyl Flooring: Considerations and specifications are similar to those for carpet and carpet adhesives. Use temporary ventilation as for carpet.

Caulks, Sealants, Glazing Compounds, Joint Fillers: Follow the procedures for carpet adhesives.

Paints: Follow the procedures for adhesives and other "wet" products. Use temporary ventilation as for carpet.

Insulation: Limit acoustical insulation to essential uses. Where acceptable, apply insulation to the exterior of ductwork. Use sound baffles rather than insulation where they will do the job. Where possible, coat thermal and fireproofing insulation materials with a smooth and impermeable membrane to reduce the adsorption of VOCs and water vapor. To reduce the potential for microbial growth, control humidity within the ducts. Prevent condensation by properly locating humidification or de-humidification equipment. Be sure that ductwork can be inspected and cleaned.

Workstation Panels: Obtain the most comprehensive test reports available from manufacturers. If no testing has been done, consider using other products. Consider possible changes in materials, airing out at the factory prior to packaging, airing out outside the building prior to installation, or conditioning in situ. Consider the need for independent testing. Consider random testing of panels arriving on site to monitor emissions.

WHAT CONSTITUTES A LOW-EMITTING MATERIAL OR PRODUCT?

Whether the emissions from any source will lead to "acceptable" indoor concentrations and occupant exposures will depend on a number of considerations, namely: (a) emission rates; (b) the toxicity or irritation potential of substances emitted; (c) physical relationships between the source, the persons present, and the space they occupy (the proximity of the source to people breathing its emissions can greatly affect the amount of dispersion and dilution of emissions, and therefore the concentrations actually breathed); and (d) the sensitivity of the occupants.

The complexity of these factors makes acceptability an essentially situation-specific issue. However, in spite of this complexity, and lack of a solid data base on acceptable concentrations of complex mixtures of substances, many builders and architects are asking for lists of, or guidelines on, "low-emitting" or "clean" materials and products.

There is not enough emission rate data to list specific recommended products. Therefore, the classification scheme in Table 1 represents engineering judgement on criteria for determining whether products are acceptably low-emitting. Acceptability in this case is based primarily on the work of Mølhave that suggested a mucous membrane irritation threshold for total organic vapors in the range of 0.16 to 5 mg/m³ (10). Assuming 2 mg/m³ to represent that range, and accounting for multiple sources, a maximum contribution from any single source type of 0.5 mg/m³ is used in Table 1. This value incorporates a somewhat greater safety factor than the 1 mg/m³ maximum contribution suggested previously (11), and is consistent with the State of Washington criterion.

STATUS AND FUTURE DIRECTIONS OF PRODUCT TESTING

Emission rate testing and exposure modeling of certain materials and products has become

TABLE 1

A CLASSIFICATION OF LOW-EMITTING MATERIALS AND PRODUCTS
(Based on emissions of total organic vapors, except as noted)

<u>Material or Product</u>	<u>Maximum Emissions*</u>
Flooring Materials	0.6 mg/h per m ²
Floor Coatings	0.6 mg/h per m ² **
Wall Materials	0.4 mg/h per m ²
Wall Coatings	0.4 mg/h per m ² **
Movable Partitions	0.4 mg/h per m ²
Office Furniture	2.5 mg/h per workstation
Office Machines (central)	0.25 mg/h per m ³ of space
Ozone emissions	0.01 mg/h per m ³ of space
Office Machines (personal)	2.5 mg/h per workstation
Ozone emissions	0.1 mg/h per workstation

* This column lists default values for use where predictive modeling of IAQ impacts is not done. For specific indoor situations, modeling is generally preferable to using these defaults, and may yield very different values for maximum emissions. Values for particularly noxious compounds will also be lower than those shown.

** Many varnishes, paints, waxes, and other wet coatings have emission factors substantially higher than this, immediately after application. These coatings might still be considered "low-emitting" if their emission factors drop below this level within several hours. However, the presence of other surfaces that adsorb coating vapors and subsequently re-emit them complicates the classification of coatings.

Basic Assumptions: Indoor air is well mixed; ventilation rate is 0.5 exchange of outdoor air per hour; maximum prudent increment in indoor concentration of organic vapors from any single source type is 0.5 mg/m³; maximum prudent increment of ozone is 0.02 mg/m³ (0.01 ppm); and volume of concern for dispersion of emissions from furniture and machines at workstations is 10 m³.

a significant step in the design of some new and renovated office buildings. Such efforts, if coupled with appropriate attention to ventilation system design and operation, aesthetic and ergonomic factors, and building maintenance, are almost certain to reduce the types of occupant complaints that characterize "sick buildings." However, our current ability to design buildings with materials and products that protect IAQ is hampered by the lack of: (a) data on emissions, and (b) clear, predictable relationships between exposure to emitted substances and health or comfort effects.

Emission factors of the type listed in Table 1 are not yet widely available from manufacturers, suppliers, or building designers. As owners and designers of large building projects require testing, a data base of such values will be developed. In time, owners or designers of small building projects will have access to these data, or at least to products that have met the requirements of large projects. If marketplace forces become sufficiently strong, even materials and products for the small homebuilder or do-it-yourselfer should be available.

In the U.S., the emphasis to date has been on carpeting, office furniture, adhesives, and coatings. In response to several widely publicized cases of IAQ problems caused by emissions from carpet, manufacturers represented by the Carpet and Rug Institute have recently committed to evaluating the emissions from their products. Individual manufacturers of other indoor items such as furniture and consumer products have also started to do emission-rate testing and exposure modeling. It is likely that there will soon be some product labeling; at a minimum, major buyers will be able to obtain data on emission rates to compare products.

Several buildings in the U.S., and presumably in other countries, will be built or renovated and furnished with materials and products that have been tested and selected for their low emission rates. The degree of success of these buildings, especially in providing good IAQ during the early months of operation when such buildings are most likely to have IAQ complaints, should be well known by the next international conference on indoor air in 1993.

In the meantime, several researchers will be investigating the feasibility of screening indoor materials and products with biological response-based tests. Human or animal exposures and cellular (*in vitro*) assays will be considered for evaluating the acceptability of indoor materials and products. Such tests will include those that measure the "olf" value of products (12), and will also include tests that might indicate acute airway, eye, and systemic responses to emissions.

REFERENCES

- (1) Tichenor, B.A., L. E. Sparks, J. B. White, and M. D. Jackson. Evaluating Sources of Indoor Air Pollution. To be published in JAPCA, April 1990.
- (2) Tucker, W. G. Emissions of Air Pollutants from Indoor Materials: An Emerging Design Consideration. In: Proceedings of the Fifth Canadian Building and Construction Congress. (Montreal, November 1988). National Research Council of Canada, Ottawa, 1988. pp. 101-109.
- (3) ASHRAE Standard 62-1989: Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating and Air-conditioning Engineers. Atlanta, 1989.
- (4) Tucker, W. G. Air Pollutants from Surface Materials: Factors Influencing Emissions, and Predictive Models. In: Healthy Buildings '88, Vol. 1, Proceedings of the Healthy Buildings '88 Conference. Swedish Council for Building Research, Stockholm, 1988. pp. 149-157.
- (5) Personal communications with John Peard, Department Labor and Industries, State of Washington. 1990.
- (6) Sparks, L.E. Indoor Air Quality Model. Version 1.0. EPA-600/8-88-097a,b (NTIS PB89-133607, -133615) (-097b is diskette). 1988.
- (7) Tichenor, B. A. Indoor Air Sources: Using Small Environmental Test Chambers to Characterize Organic Emissions from Indoor Materials and Products. EPA-600/8-89-74. (NTIS PB90-110131). 1989.
- (8) Levin, H. Building Materials and Indoor Air Quality. Occupational Medicine: State of the Art Reviews. Hanley & Belfus, Philadelphia, Vol. 4, No.4, Oct-Dec. 1989. pp. 667-693.
- (9) Levin, H. (Ed.), Indoor Air Quality Update. Cutter Information Corp., February 1990.

- (10) Mølhave, L. Volatile Organic Compounds as Indoor Air Pollutants. In: R. B. Gammage and S.V. Kaye (eds.), Indoor Air and Human Health. Lewis Publishers, Chelsea, MI, 1985. pp. 403-414.
- (11) Tucker, W. G. Research Overview: Sources of Indoor Air Pollutants. In: Proceedings of the ASHRAE Conference IAQ '86. ASHRAE, Atlanta, 1986. pp. 395-404.
- (12) Fanger, P. O. Introduction of the Olf and the Decipol Units to Quantify Air Pollution Perceived by Humans Indoors and Outdoors. Energy and Buildings, 12, 1988. pp. 1-6.